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Alfred L. DeCicco

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ABSTRACT

Stock status of Arctic grayling *Thymallus arcticus* was investigated in the Snake, Nome, Pilgrim and Sinuk rivers of the Seward Peninsula during 1992. Population abundance, age composition, length composition and length-at-age were estimated. Survival rates from 1989 to 1990 and from 1990 to 1991 were estimated for Arctic grayling in the Sinuk River.

The number of Arctic grayling over 249 millimeters in fork length was estimated at 2,418 fish (standard error = 200) in a 48 kilometer section of the Snake River. The density was 50 fish/kilometer. Captured Arctic grayling ranged from 174 to 496 millimeters in fork length and from 2 to 11 years in age.

The estimated abundance of Arctic grayling over 269 millimeters in fork length in a 30 kilometer section of the Nome River was 725 (standard error = 93) or 24 fish/kilometer. Captured Arctic grayling ranged from 223 to 490 millimeters in fork length and from 2 to 12 years in age.

In a 12 kilometer section of the Pilgrim River, the estimated abundance of Arctic grayling > 269 millimeters in fork length was 1,263 fish (standard error = 199) or 105 fish/kilometer. Captured fish ranged from 159 to 489 millimeters in fork length and from 3 to 12 years of age.

The estimated abundance of Arctic grayling > 324 millimeters in fork length in a 40 kilometer section of the Sinuk River just prior to August 1991 was 919 fish (standard error = 196) or 23 fish/kilometer. Arctic grayling sampled in 1992 ranged from 104 to 521 millimeters in fork length and from 1 to 15 years in age. The modified Jolly - Seber estimate of survival from 1989 to 1990 was 1.00 (standard error = 0.05) and from 1990 to 1991 was 0.65 (standard error = 0.13).

KEY WORDS: Arctic grayling, *Thymallus arcticus*, population abundance, age composition, length composition, growth, Seward Peninsula, Sinuk River, Nome River, Snake River, Pilgrim River, survival.

INTRODUCTION

The Seward Peninsula-Norton Sound area of western Alaska supports the second largest amount of recreational fishing effort in the Arctic-Yukon-Kuskokwim (AYK) region. From 1980 to 1991, an average of 15,142 freshwater angler-days of sport fishing effort occurred in this area (Mills 1981-1992, Figure 1). Reported freshwater fish harvests consisted primarily of Dolly Varden *Salvelinus malma*, Arctic grayling *Thymallus arcticus*, pink, coho, chum and chinook salmon *Oncorhynchus spp.*, northern pike *Esox lucius*, whitefish *Coregonus spp.*, and burbot *Lota lota*. From 1980 to 1990, Arctic grayling have comprised an average of 20% of the harvest of these species, and was 19% in 1991 (Table 1).

The Seward Peninsula is the only area in Alaska outside of Bristol Bay which regularly produces trophy-sized Arctic grayling. Of 119 Arctic grayling registered with the Alaska Department of Fish and Game (ADF&G) Trophy Fish Program between 1967 and 1991, 30 (25%) were from the Seward Peninsula (ADF&G *Unpublished*).

Seward Peninsula contains approximately 420 km of gravel roads which are maintained by the Alaska Department of Transportation and Public Facilities from May through September. These roads originate in Nome and traverse the Seward Peninsula in three general directions: the Beam Road extending to the north, the Teller Road to the west and the Council Road to the east (Figure 2). This road system sets Nome apart from most other rural Alaskan communities and provides angler access to many streams on the Seward Peninsula. Although roads in the Nome area are not connected to the state highway system.

As indicated by harvest statistics (Table 1), sport fishing pressure at accessible Seward Peninsula and Norton Sound streams can be substantial. Subsistence harvests of Arctic grayling, although not monitored, are also substantial. Local anglers and ADF&G staff in Nome believe that the abundance of large-sized Arctic grayling is declining in some streams. This concern led the Alaska Board of Fisheries to promulgate a regulation in 1988 which reduced the daily bag limit of Arctic grayling on the Seward Peninsula to five per day, five in possession, with only one over 15 inches (381 mm total length).

Studies on the basic life history and angler utilization of fish on the Seward Peninsula were initiated by ADF&G in 1977 and continued through 1979. During this period nine streams were surveyed for fish presence and 147 Arctic grayling were sampled for age, weight and length. Angler counts were conducted periodically on 15 different streams (Alt 1978, 1979, 1980). Between 1979 and 1984, 88 Arctic grayling from the Fish/Niukluk rivers were sampled for age, length and weight (Alt 1986). During 1988, a project was initiated to survey Arctic grayling stocks on Seward Peninsula rivers and to estimate average catch and harvest per unit effort of Arctic grayling on those streams (Merritt 1989). A total of 887 Arctic grayling were tagged and sampled for length and age on the Nome, Snake, Sinuk, Solomon, Eldorado, Pilgrim, Kuzitrin, Niukluk and Fish rivers and Boston Creek. In addition, 32 anglers were interviewed. During 1989, Arctic grayling were sampled on the Niukluk and Sinuk rivers for age at length and size composition and abundance was estimated for a section of the Niukluk River (DeCicco 1990). During 1990, abundance as well as age and size composition of Arctic grayling were

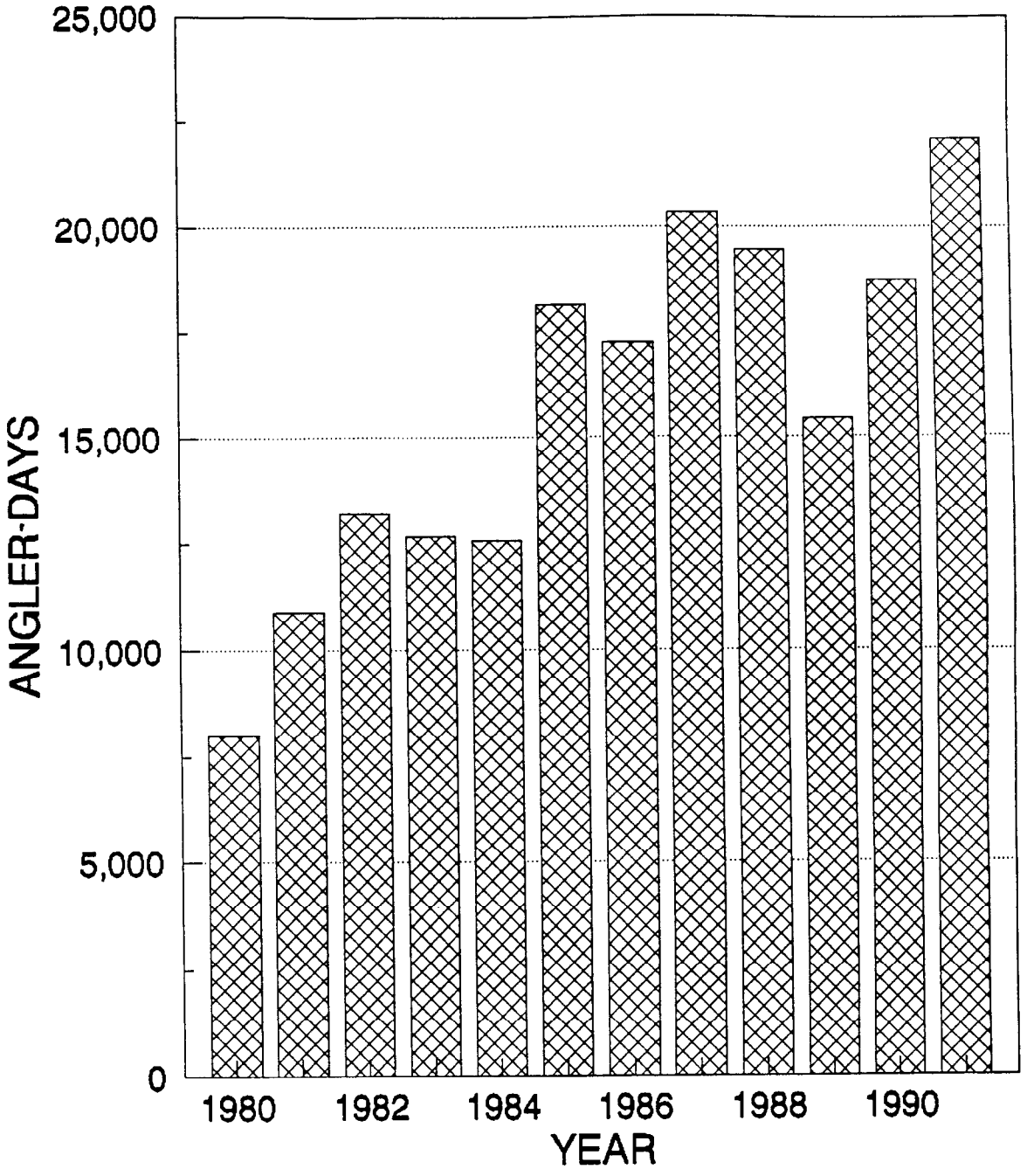

Figure 1. Estimated freshwater sport fishing effort on Seward Peninsula and Norton Sound streams, 1980-1991.

Table 1. Estimated freshwater sport fish harvests for Seward Peninsula and Norton Sound streams, 1980 - 1991. Data from Alaska statewide sport fish harvest survey (Mills 1981 - 1992).

Year	Days Fished	Harvests (Catches) in Number of Fish					
		Salmon All species	Dolly Varden	Arctic Grayling	Northern Pike	Burbot	Whitefish
1980	7,968	10,840	5,811	1,635	284	0	353
1981	10,879	6,564	3,981	2,104	303	0	123
1982	13,198	19,757	6,498	6,225	210	0	597
1983	12,678	10,189	9,779	8,241	798	0	148
1984	12,558	13,881	4,260	2,349	208	13	39
1985	18,141	3,401	5,695	4,501	56	175	70
1986	17,257	9,610	5,381	4,042	699	0	510
1987	20,381	5,415	5,506	4,600	906	0	272
1988	19,456	10,460	4,437	4,873	564	36	655
1989	15,443	8,548	7,003	4,205	648	10	453
1990[a]	18,720	11,227 (24,705)	3,765 (9,118)	1,378 (6,119)	1,957 (4,145)	33 (33)	299 (315)
1991[a]	22,118	8,928 (15,561)	10,365 (25,425)	5,121 (23,160)	1,429 (4,257)	116 (116)	1,357 (1,409)
Mean	15,733	9,904 (20,133)	6,040 (17,272)	4,106 (14,639)	672 (4,201)	32 (75)	406 (862)

[a] Harvest and (catch) were both estimated.

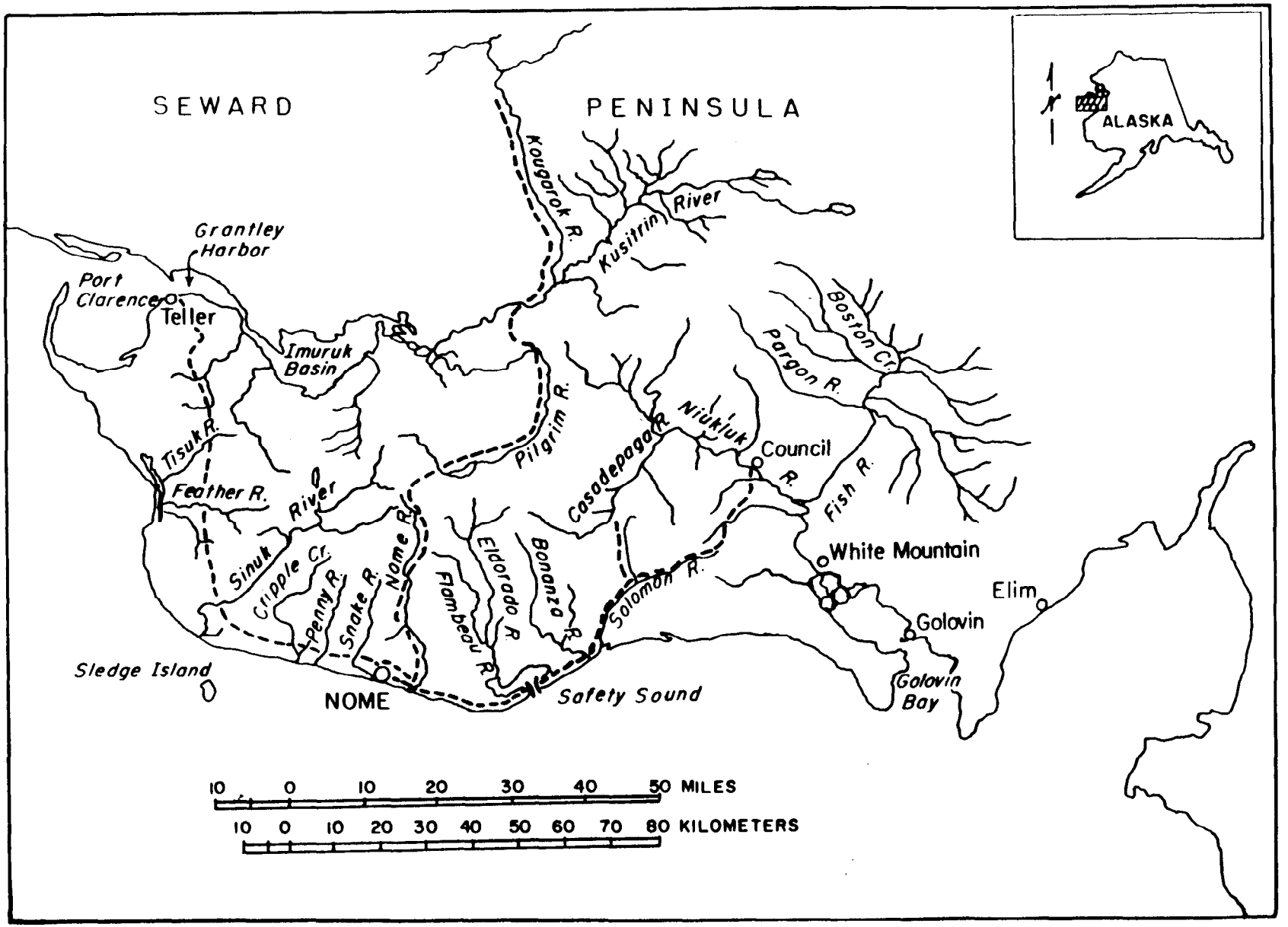

Figure 2. The southern Seward Peninsula showing roads and road accessible waters.

estimated on the Niukluk, Fish, Pilgrim and Sinuk rivers (DeCicco 1991). During 1991, population abundance, age and size composition were estimated on the Nome, Snake, Pilgrim and Sinuk rivers (DeCicco 1992).

This project is a continuation of the work begun in 1988 by Merritt (1989). Long term goals of the project are:

1) to define sustainable yield for Arctic grayling stocks in Seward Peninsula drainages; and,

2) to achieve sustainable yield sport fisheries for Arctic grayling populations through regulation.

Project objectives in 1992 were:

1) to estimate the abundance, age and length composition, and mean length-at-age of Arctic grayling > 149 mm FL in the following waters:

   a. a 48-km section of the Snake River;

   b. a 30-km section of the Nome River;

   c. a 12-km section of the Pilgrim River downstream of the Beam Road bridge; and,

2) to estimate the abundance, age and length composition, and mean length-at-age of Arctic grayling > 249 mm FL in a 40-km section of the Sinuk River in 1991.

Additionally, estimates of survival from 1990 to 1991 were calculated for the Sinuk River stock.

METHODS

Sampling Gear and Techniques

Arctic grayling were sampled using hook and line in all rivers and using a 50-m x 2-m, 6.5-mm mesh beach seine on the Snake, Nome and Pilgrim rivers (Figures 3 and 4). Arctic grayling residing in the Snake River were also sampled using a pulse-DC electrofishing system mounted on a 5.4-m-long river boat. Input voltage (240 VAC) was provided by a 2,900 W single-phase Kawasaki Model GA 3200-A gas powered generator. A variable voltage pulsator (Coffelt Manufacturing Mark-10) was used to generate output current. Six anodes were constructed of 9.5-mm diameter twisted steel cable 1.5 m long inside 19-mm diameter flexible conduit and attached equidistantly to the 3.5-m cross member of a 3.5-m-long retractable "T-boom" attached to a platform on the bow of the boat. The aluminum hull of the river boat was used as the cathode. Output voltages varied between 180 and 240 VDC and amperage varied from 1.8 to 4 amp. The pulse rate was held at 60 Hz.

Arctic grayling from a 40-km section of the Sinuk River (Figure 5) were sampled with hook and line during six days in early August. Access to the

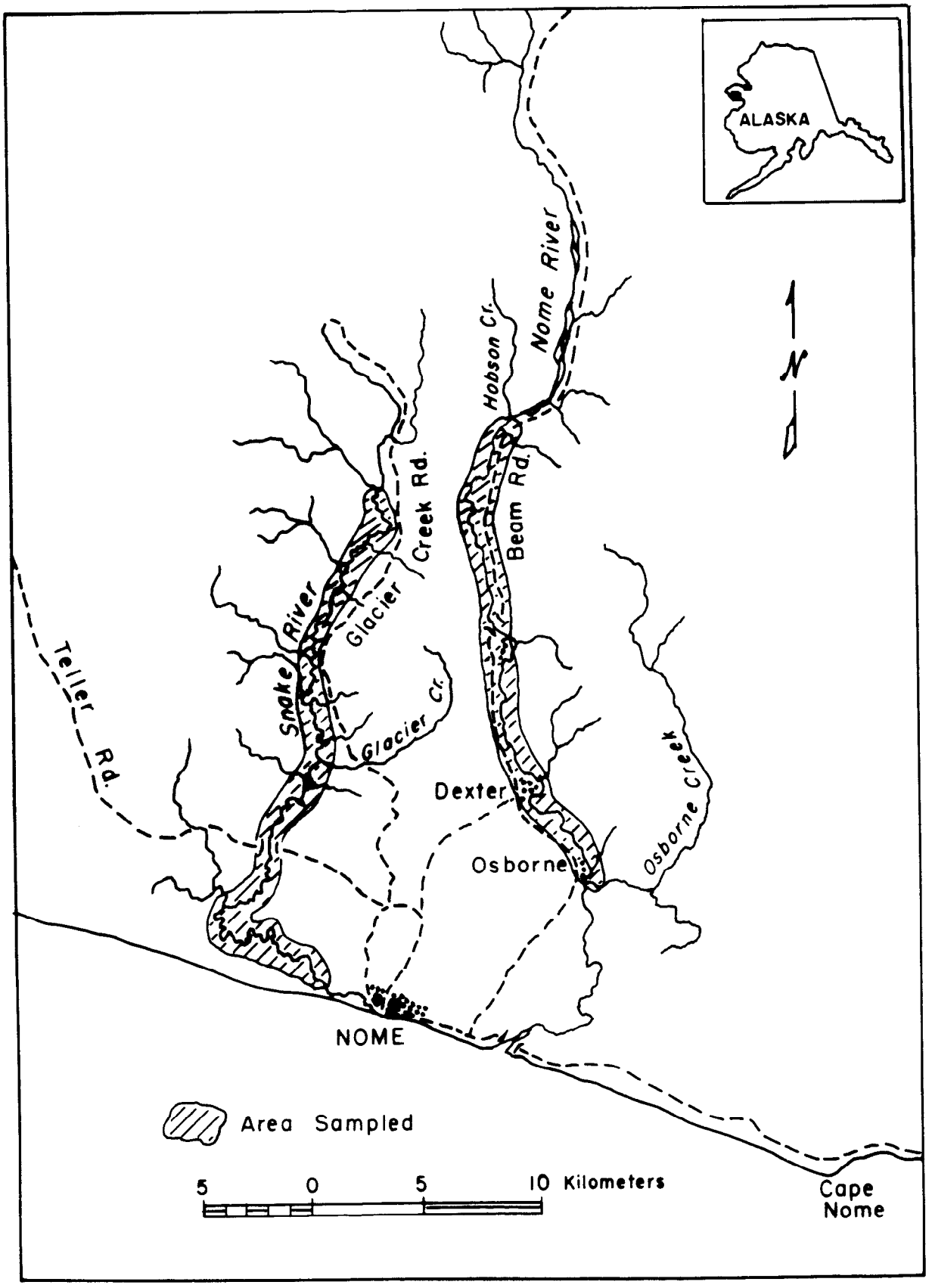

Figure 3. The Snake and Nome rivers with area sampled during 1992.

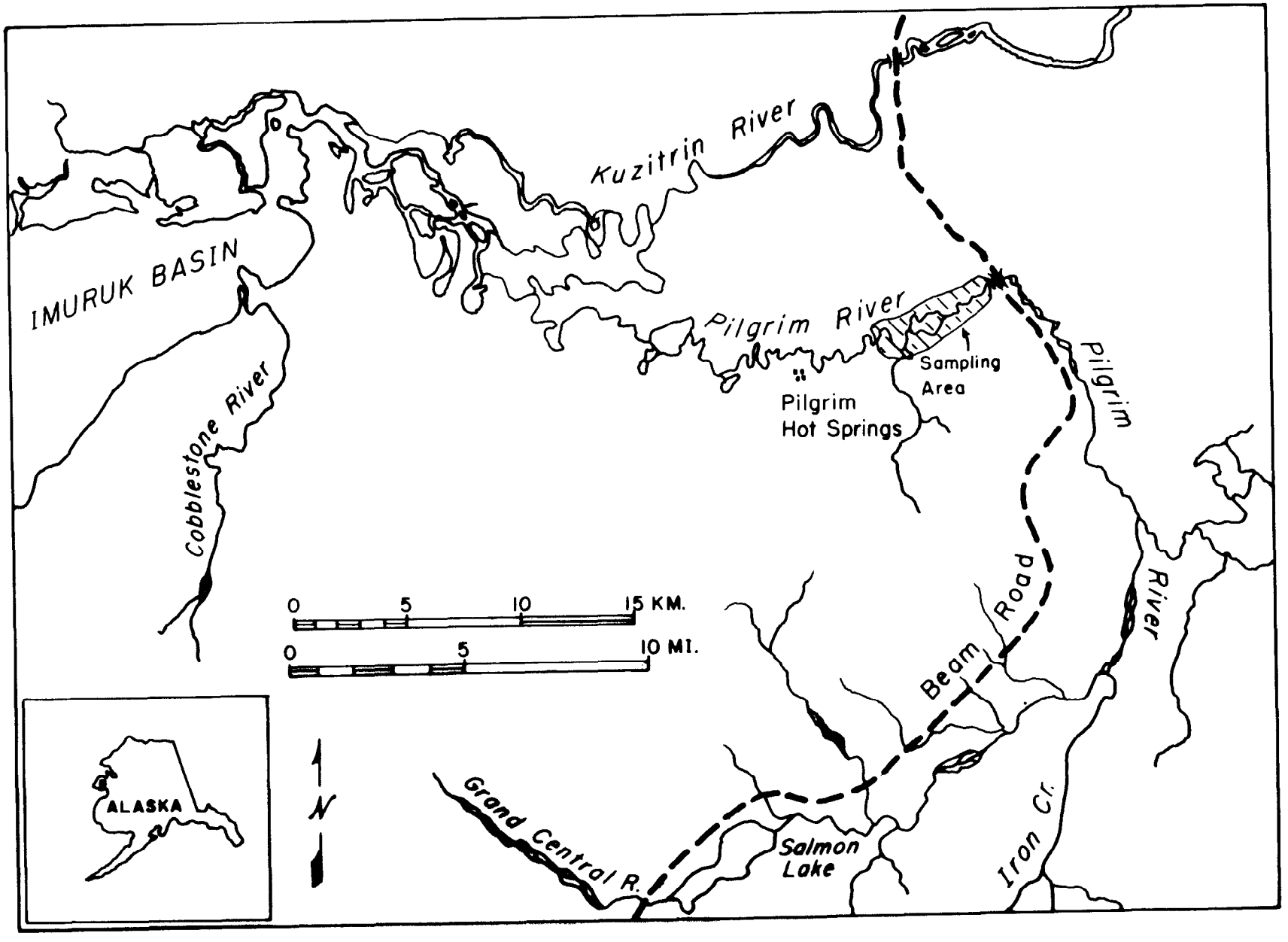

Figure 4. The Pilgrim River with area sampled during 1992.

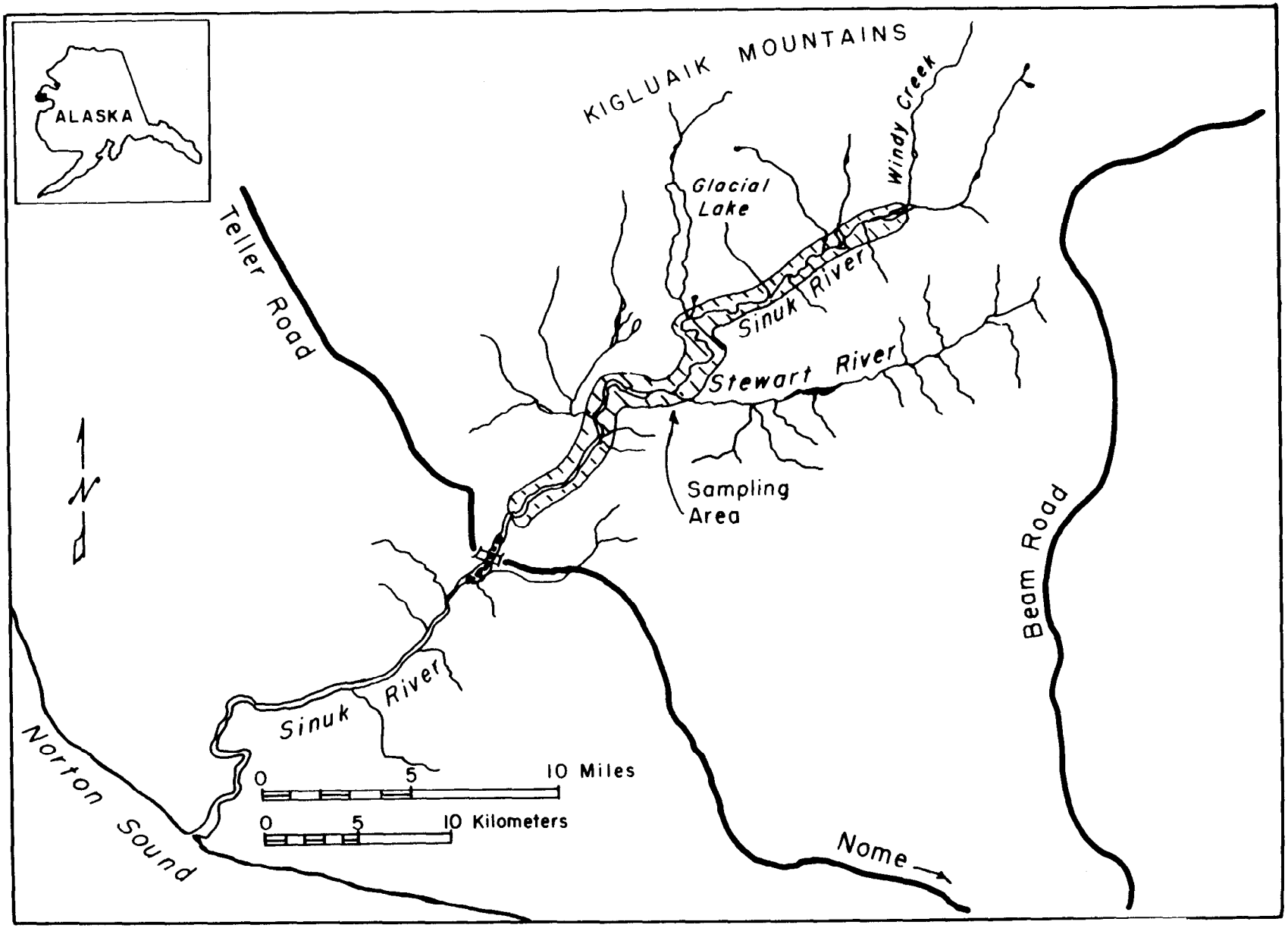

Figure 5. The Sinuk River with area sampled during 1991 and 1992.

headwaters of the river was gained using a Bell Jet Ranger helicopter under contract to the Bureau of Land Management. The river was floated using a 3.7-m Avon Redshank inflatable raft and oars.

Each Arctic grayling was measured to the nearest mm in fork length (FL). Fish over 149 mm FL were tagged with individually numbered Floy FD-67 internal anchor tags which were inserted such that the "T" anchor locked between the base of adjacent dorsal fin rays. Each fish was also marked with a partial fin clip (see Appendix A1 for a summary of dates and marks applied). Scales for age determination were taken from the left side of the fish approximately midway between the dorsal fin and the lateral line down from the posterior insertion of the dorsal fin.

Data were recorded on standard ADF&G Tagging-Length forms (version 1). Scales were cleaned with detergent and water, mounted on gummed cards and acetate impressions were made (30 seconds at 7,000 kg/cm^2, at 100° C). Ages were determined by counting annuli from the acetate impressions using a microfiche reader. All scale impressions were read by one technician in Fairbanks. Some readings were checked by the project leader. If the technician and project leader could not agree on the age of the fish, a third reading was made by the project leader. If two readings did not agree, the age sample was discarded. Regenerated scales were not aged. Data files were archived with ADF&G Research and Technical Services (RTS) in Anchorage (Appendix B1).

Population Abundance Estimates

A modified Petersen mark-recapture experiment (Bailey 1951, 1952) was used to estimate the abundance of Arctic grayling in sections of the Snake, Nome and Pilgrim rivers (Figures 3 and 4). A four year modified Jolly-Seber model was used to estimate the abundance of Arctic grayling in the study section of the Sinuk River (Figure 5).

Modified Petersen Mark-Recapture Estimates:

Sampling for the two-event population estimates was performed in each of the river sections. The entire length of each river section was sampled during both the mark and recapture events.

The assumptions necessary for the accurate estimation of abundance in a closed population are (after Seber 1982):

1. there is neither mortality nor recruitment between sampling events (closed population);

2. fish have an equal capture probability in the first event or the second event, or marked fish mix completely with unmarked fish during the second sampling event;

3. marking does not affect capture probability in the second event;

4. marks are not lost between events; and,

5. marked fish can be recognized from unmarked fish.

Assumption 1 could not be tested directly. It was assumed that neither mortality nor recruitment occurred because both events were close together in time. Assumptions 2 and 3 were tested with two Kolmogorov-Smirnov (K-S) two-sample tests (Conover 1980) to determine if capture probability was a function of fish size, and by comparing marking fractions by river section to see if either of the first two parts of assumption two appeared true. The first K-S test compared the cumulative length distribution of fish marked in the first sampling event (mark event) with the cumulative length distribution of marked fish recaptured during the second sampling event (recapture event). In the second K-S test, the cumulative length distribution of fish captured during the marking event was compared to the cumulative length distribution of all fish captured during the recapture event (Seber 1982). If the results of the first K-S test showed that the samples were different ($P < 0.05$), size selectivity between samples was indicated and the experiment was stratified by fish size. If the results of the second K-S test showed that the samples were different ($P < 0.05$), recruitment, migration, or some other factor affecting the size distribution of the two samples was indicated. A more complete tracking of test results and consequences is contained in Appendix A2. To test whether capture probabilities varied by river section, the number of recaptured fish to the number of fish examined during the second event (by river section) were examined using contingency table tests. In rivers where the probabilities of capture were different by area, abundance estimates were stratified by area using the methods of Darroch (1961) for point estimates, and variances were calculated by the bootstrap method of Efron (1982). All fish were released within the reach of the river in which they were captured. To meet conditions of assumption 4, all fish were double marked with a floy tag and an appropriate finclip (Appendix A1). Finclips were chosen so as to not duplicate those used for fish from a given river in previous years. Assumption 5 was met by the close examination of all fish and by the presence of the double mark.

Population abundance and the approximate variance of the estimate were calculated with the following formulas (Seber 1982):

$$\hat{N} = \frac{M(C+1)}{(R+1)} \qquad (1)$$

$$\hat{V}[N] = \frac{M^2(C+1)(C-R)}{(R+1)^2(R+2)} \qquad (2)$$

where:

M = the number marked during the first event;

C = the number captured during the second event;

R = the number captured during the second event with marks from the first event;

$\hat{N}$ = the estimated abundance of Arctic grayling during the first event; and,

V = the approximate variance of the abundance estimate.

Modified Jolly-Seber Mark-Recapture Estimates:

The Jolly-Seber model (Jolly 1965, Seber 1965) was used for estimating the abundance of Arctic grayling in the Sinuk River and survival between 1989 and 1990. The assumptions necessary for accurate estimation of abundance with the Jolly-Seber model are paraphrased as follows (after Seber 1982):

1) every fish in the population has the same probability of capture in the *i*th sample;

2) every marked fish has the same probability of surviving from the *i*th to the $(i + 1)$ sample and being in the population at the time of the $i + 1$ sample;

3) every fish caught in the *i*th sample has the same probability of being returned to the population;

4) marked fish do not lose their marks between sampling events and all marks are reported on recovery; and,

5) all samples are instantaneous (sampling time is negligible).

Assumptions 1 and 2 were interrelated because differential vulnerability to sampling gear and changes in survival rate by size (or age) of fish cannot be separately detected. Both assumptions were thus simultaneously tested with a goodness-of-fit test devised by Pollock et al. (1985). If the data fit the Jolly-Seber model (failure to reject the null hypothesis of goodness-of-fit), the data were used to estimate abundance, survival, and recruitment. If the data did not fit the Jolly-Seber model, probable causes of departure were investigated.

Assumption 3 was assumed to be valid because the number of fish killed while sampling, or released alive without a tag, has been less than 10 fish per year since 1989. Assumption 4 was met by double marking of Arctic grayling with Floy tags and partial fin clips. Assumption 5 was met by restricting each sampling event to 10 days or less, and it is believed that additions and losses to and from the population during each event were negligible.

The Jolly-Seber procedures for estimating abundance and survival rate were obtained for 1991 by first calculating the number of Arctic grayling marked in the population just prior to the 1991 sample ($\hat{M}_{1991}$):

$$\hat{M}_{1991} = \frac{R_{1991}\, z_{1991}}{r_{1991}} + m_{1991} \qquad (4)$$

where: R_{1991} = the number of marked Arctic grayling released after the 1991 sample;

z_{1991} = the number of different Arctic grayling caught before the 1991 sample, not seen during the 1991 sample, but subsequently recaptured during 1992;

r_{1991} = the number of Arctic grayling recaptured in 1992 that were released in the 1991 sample (recaptures from R_{1991}); and,

m_{1991} = the number of marked Arctic grayling caught during the 1991 sample (recaptures from 1990).

With estimates of M_i, survival rate was calculated from the relation of those surviving to 1991 from those initially marked and released in 1990:

$$\hat{\phi}_{1990} = \frac{\hat{M}_{1991}}{R_{1990}} \qquad (5)$$

where: R_{1990} = the number of marked Arctic grayling released after the 1990 sample.

Abundance was then calculated by substituting estimated number of marked fish alive for the number of marked fish released in a standard Petersen estimate:

$$\hat{N}_{1991} = \frac{\hat{M}_{1991}\, n_{1991}}{m_{1991}} \qquad (6)$$

where: n_{1991} = the number of Arctic grayling caught during the 1991 sample.

Point estimates of the above parameters were calculated using the program RECAP (Buckland 1980). Buckland's (1980) approach in RECAP modifies the standard estimation equations so that parameter estimates fall within possible realistic domains (e.g. $0 \leq \phi \leq 1$). The program was also used to calculate nonparametric bootstrap (Efron 1982) estimates of the standard errors for the parameters using 400 bootstrap replications.

Bias in Estimates of Number at Age:

Low numbers of small sized fish were marked and examined in most rivers. In order to minimize bias in estimates of the numbers of small sized fish in the lowest RSD category (Gabelhouse 1984), the length of the smallest recaptured fish was used as a guideline for the minimum size for which the mark-recapture estimate would be made. When the smallest recaptured fish was close to a minimum RSD length category, that minimum RSD category size was chosen as the lower bound for the mark-recapture estimate. This allowed a minimum of bias to be introduced into estimates of number at age for the small sized fish in an RSD category. Kolmogorov - Smirnov two sample tests were then run for those lengths of fish not culled from the experiment and the methods previously outlined were followed in the analyses.

Age Composition and Numbers at Age

Arctic grayling were collected and sampled to estimate age composition in each river. The proportions of fish in each age were estimated as multinomial proportions (Cochran 1977). The proportion at each age j was estimated as:

$$\hat{p}_j = \frac{n_j}{n} \quad (7)$$

where:

n_j = the number in the sample at age j;

n = number of fish successfully aged; and,

p_j = the estimated fraction of the population at age j.

The unbiased variance of this proportion was estimated as:

$$V[\hat{p}_j] = \frac{\hat{p}_j(1-\hat{p}_j)}{n - 1} \quad (8)$$

Abundance of Arctic grayling by age was estimated as follows:

$$\hat{N}_j = \hat{p}_j(\hat{N}); \quad (9)$$

where:

$\hat{N}_j$ = estimated number of fish ≥ a certain size and at age j;

$\hat{N}$ = estimated abundance of Arctic grayling ≥ a certain size.

Variances for Equation 9 were estimated using Goodman's (1960) formula:

$$V[\hat{N}_j] = (\hat{p}_j^2 V[\hat{N}]) + (\hat{N}^2 V[\hat{p}_j]) - (V[\hat{p}_j]V[\hat{N}]); \quad (10)$$

where:

$V[\hat{N}]$ was obtained from the mark recapture analyses.

Length Composition

Length composition of Arctic grayling residing in each river was estimated as RSD categories. The RSD categories used for Arctic grayling were: "stock" (150 to 269 mm FL); "quality" (270 to 339 mm FL); "preferred" (340 to 449 mm FL); "memorable" (450 to 559 mm FL); and "trophy" (> 559 mm FL). Estimates of the proportion of fish in RSD categories followed the same procedures used for age composition (equations 7 and 8). Abundance estimates by RSD category were calculated using equations 9 and 10.

Mean Length-at-Age

Mean length at age was calculated as the arithmetic mean length of all fish assigned the same age. Samples were combined across years to increase sample sizes. Standard deviations of the mean lengths of each age class were calculated using standard normal procedures.

RESULTS

Population Abundance Estimates

The abundance of Arctic grayling in 1992 was estimated in the Snake, Nome, and Pilgrim rivers. An abundance estimate germane to 1991 was calculated for Arctic grayling residing in the Sinuk River.

Snake River:

The marking run on the Snake River (Figure 3) was conducted during seven days in early July using electrofishing, beach seine, and hook and line. The recapture event was conducted during a six day period in August after a four week hiatus using the same gear types. A relatively long interval between sampling events (four weeks) was allowed to promote more complete mixing of fish between sampling events. Since essentially the entire mainstem river was sampled, the possibility that fish migrated into or out of the sampling area was minimized. Fishing success was good during both events. The smallest of 496 Arctic grayling marked was 214 mm FL and the smallest of 671 Arctic grayling examined in the second event was 174 mm FL. The smallest fish recaptured from the Snake River was 250 mm FL. The abundance estimate was calculated for Arctic grayling >249 mm FL.

In the 48 km section of the Snake River from Goldbottom Creek downstream to the Nome airport, the estimated abundance of Arctic grayling > 249 mm FL (Bailey model) was 2,418 fish (SE = 200, CV = 8.3%). Density of Arctic grayling in the mainstem area sampled was 50 fish/km. A total of 466 Arctic grayling > 249 mm FL were marked during the first sampling event (1 to 10 July). During the recapture event (10 to 15 August), 606 Arctic grayling > 249 mm FL were examined of which 116 had tags from the marking event. Five fish (4.3%) were encountered with tag losses from the first event. However, 32 fish had lost their tags out of 230 fish (14%) originally marked in 1991 and two fish originally marked in 1988 had lost their tags. No fish were killed during sampling.

The river was divided into five sampling sections. Equal probability of capture of Arctic grayling by river section was examined through contingency tables comparing the numbers of new fish examined in the second sampling event (total examined - recaptures) and numbers of recaptured fish by river section (sections 4 and 5 were collapsed so four sections were examined). Probabilities of capture were found to be different (χ^2 = 15.95, df = 3, $P < 0.005$), for the four sections. A lower number of fish marked in section 1 were recaptured than expected, and higher than expected numbers of fish were recaptured in sections 2 and 3.

Kolmogorov-Smirnov two sample tests of the cumulative length distributions of Arctic grayling > 249 mm FL marked versus those recaptured during the recapture event (test 1) and of those captured during the marking event versus those examined in the recapture event (test 2) did detect significant differences (test 1: $D = 0.15$, $P = 0.04$, $n_1 = 467$, $n_2 = 116$; test 2: $D = 0.24$, $P < 0.001$, $n_1 = 606$, $n_2 = 467$; Figure 6). These tests indicated that the estimate of abundance should be stratified.

Since the above tests indicated incomplete mixing and the need for stratification, an abundance estimate stratified by area (four areas) and by size of fish (two size groups) was calculated. Because of low numbers of recaptures in some of the areas, the Darroch estimator was not able to invert 35% of the matrices during bootstrap calculations and the estimated variance was very large. An abundance estimate stratified by size was then calculated and compared to the unstratified estimate. Since the estimates were similar (within 110 fish) and the variance of the stratified estimate was more than five times larger, the unstratified estimate was chosen.

Nome River:

Arctic grayling residing in the Nome River (Figure 3) were captured during six days in mid-July using beach seine and hook and line fishing techniques and marked. The recapture event was conducted during four days after a six day hiatus. The smallest of 118 Arctic grayling marked in the Nome River was 277 mm FL and the smallest of 309 Arctic grayling examined during the second event was 223 mm FL. The smallest fish recaptured from the Nome River was 286 mm FL. To minimize bias in applying the estimate to RSD categories the abundance estimate was computed for Arctic grayling > 269 mm FL.

In the 30 km section of the Nome River from Hobson Creek to Osborne, the estimated abundance of Arctic grayling >269 mm FL (Bailey model) was 725 fish (SE = 93, CV = 12.8%). Density of Arctic grayling in the mainstem area sampled was 24 fish/km. A total of 118 Arctic grayling >269 mm FL were marked during the first event (12 to 20 July). During the recapture event (27 to 30 July) 306 Arctic grayling >269 mm FL were examined of which 49 had tags from the marking event. No tag losses from the first sampling event were detected in the second sampling event, however, four out of 82 fish originally marked in 1991 (5%) were missing tags and three out of six fish originally marked in 1988 were missing tags. No Arctic grayling were killed during sampling on the Nome River in 1992.

A Kolmogorov-Smirnov two sample test of the cumulative length distributions of Arctic grayling > 269 mm FL marked versus those recaptured during the recapture event (test 1) failed to detect significant differences $D = 0.12$, $P = 0.67$, $n_1 = 118$, $n_2 = 49$. Since a similar test of the cumulative length distributions of Arctic grayling marked in the first sampling event versus those examined in the second sampling event (test 2) did detect significant differences (test 2: $D = 0.25$, $P < 0.001$, $n_1 = 118$, $n_2 = 306$; Figure 7), fish from the second sample were used to estimate age and length composition.

The Nome River was divided into three sampling sections. Equal probability of capture of Arctic grayling by river section was examined with contingency tables as before. Sections 2 and 3 were collapsed because only two fish out of 309 were captured in section 2 during the second event, so only two

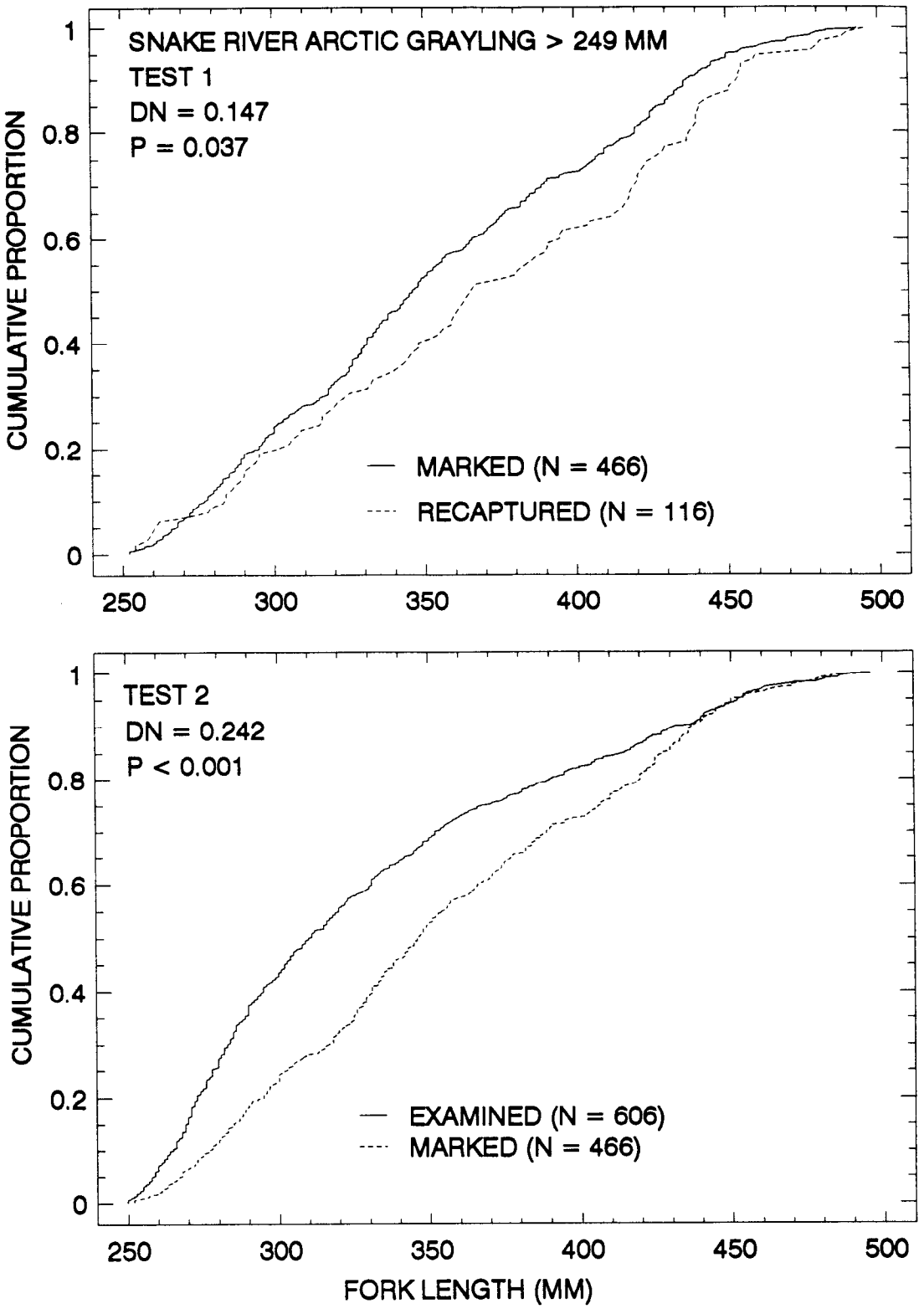

Figure 6. Cumulative length distribution plots (tests 1 and 2) of Arctic grayling >249 mm FL sampled from the Snake River in 1992.

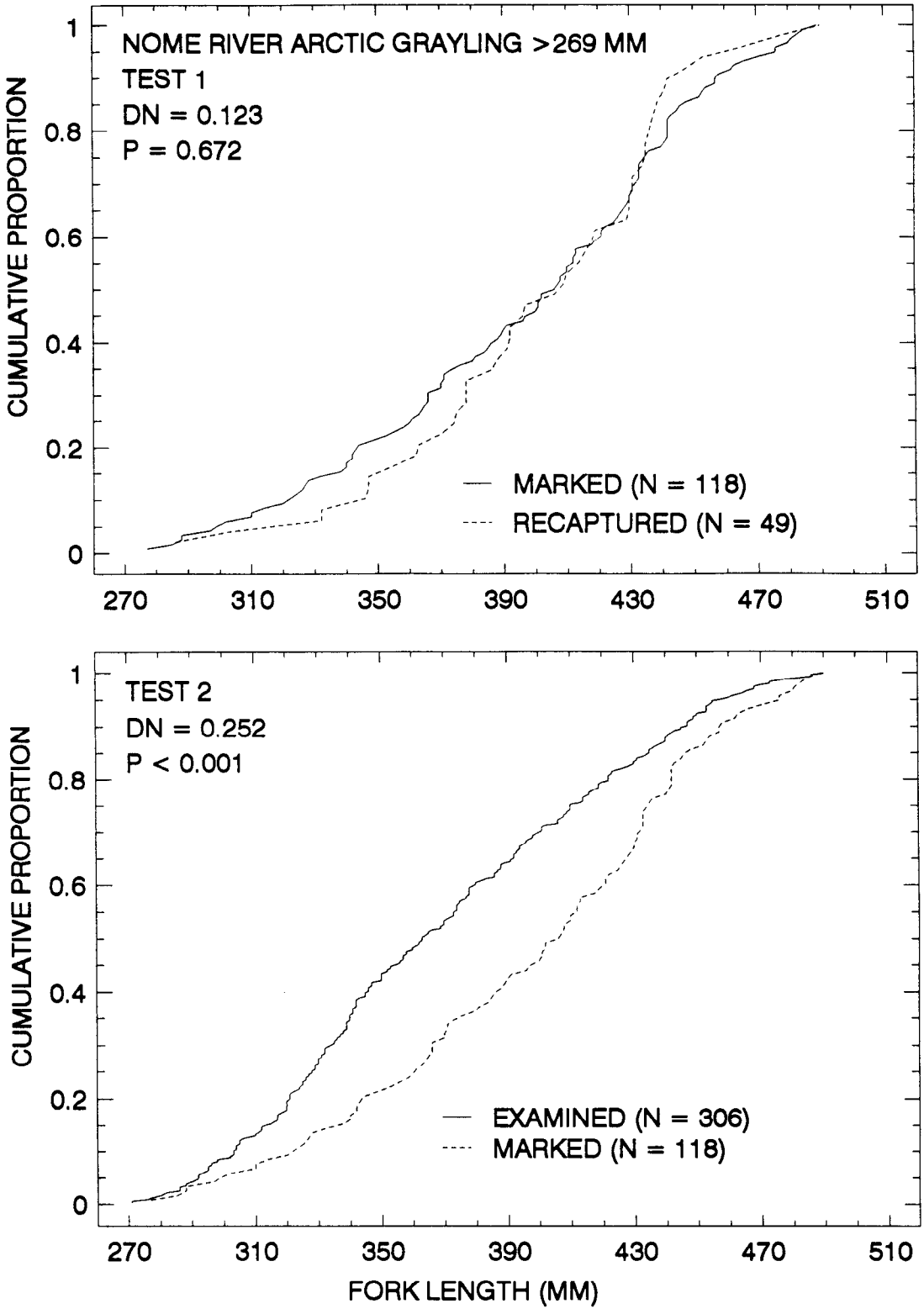

Figure 7. Cumulative length distribution plots (tests 1 and 2) of Arctic grayling >269 mm FL sampled from the Nome River in 1992.

sections were examined. Because probabilities of capture were not found to be different (χ^2 = 2.02, df = 1, P = 0.155), for the two sections, a single unstratified abundance estimate was calculated for Arctic grayling >269 mm FL.

Pilgrim River:

The marking run on the Pilgrim River (Figure 4) was conducted during a four day period in late July (see Appendix A1) and the recapture event was conducted during a four day period in August after a ten day hiatus. Beach seine and hook and line gear were used in combination to capture fish. Enough fish were marked, examined and recaptured to calculate an abundance estimate within the desired precision criteria. The smallest of 204 Arctic grayling marked was 159 mm FL and the smallest of 235 Arctic grayling examined during the second event was 232 mm FL. The smallest marked fish recaptured from the Pilgrim River was 262 mm FL, but only one was < 270 mm FL. Following the rationale provided earlier, the abundance estimate for the Pilgrim River was computed for Arctic grayling > 269 mm FL.

In the 12 km section of the Pilgrim River downstream from the Beam Road bridge, the estimated abundance of Arctic grayling > 269 mm FL (Bailey model) was 1,263 fish (SE = 199, CV = 15.8%). Density of Arctic grayling in the mainstem area sampled was 105 fish/km. A total of 193 Arctic grayling > 269 mm FL were marked during the first event (21 to 24 July). During the recapture event (3 to 6 August), 215 Arctic grayling (> 269 mm FL) were examined of which 32 had tags from the marking event. No tag loss from the first tagging event was detected. However, three of 52 recaptured 1991 fish (6%) had lost their tags, one tag loss from 26 recaptures (3.8%) of fish tagged in 1990, and two tag losses from 10 recaptures of 1988 fish (20%) were encountered. One Arctic grayling was killed incidental to sampling in 1992.

Kolmogorov-Smirnov two sample tests of the cumulative length distributions of Arctic grayling > 269 mm FL marked versus those recaptured during the recapture event (test 1) and of those marked in the first event and those examined in the second event (test 2) failed to detect significant differences (test 1: D = 0.18, P = 0.33, n_1 = 193, n_2 = 32; test 2: D = 0.07, P = 0.66, n_1 = 213, n_2 = 193; Figure 8). A single unstratified abundance estimate was calculated for Arctic grayling > 269 mm FL, and fish from both samples were used to estimate age and length composition (Appendix A5).

Sinuk River:

The Sinuk River (Figure 5) was floated during seven days in August to collect Arctic grayling for a Jolly-Seber abundance estimate germane to 1991 (Appendix A6). Hook and line gear was used to capture 289 Arctic grayling of which 41 carried 1991 marks, 14 carried 1990 marks and 12 carried 1989 marks. The smallest Arctic grayling recaptured in 1991 at time of marking in 1989 and 1990 was 325 mm FL. The abundance estimate germane to 1990 was therefore calculated for fish > 324 mm FL. In order for abundances to be comparable across years, the abundance estimate for 1991 was calculated for fish > 324 mm FL even though the smallest fish recaptured in 1992 was 309 mm FL when marked in 1991. One tag loss from 1990 and six tag losses from 1991 were observed in 1992. Eight Arctic grayling were killed incidental to sampling in 1992.

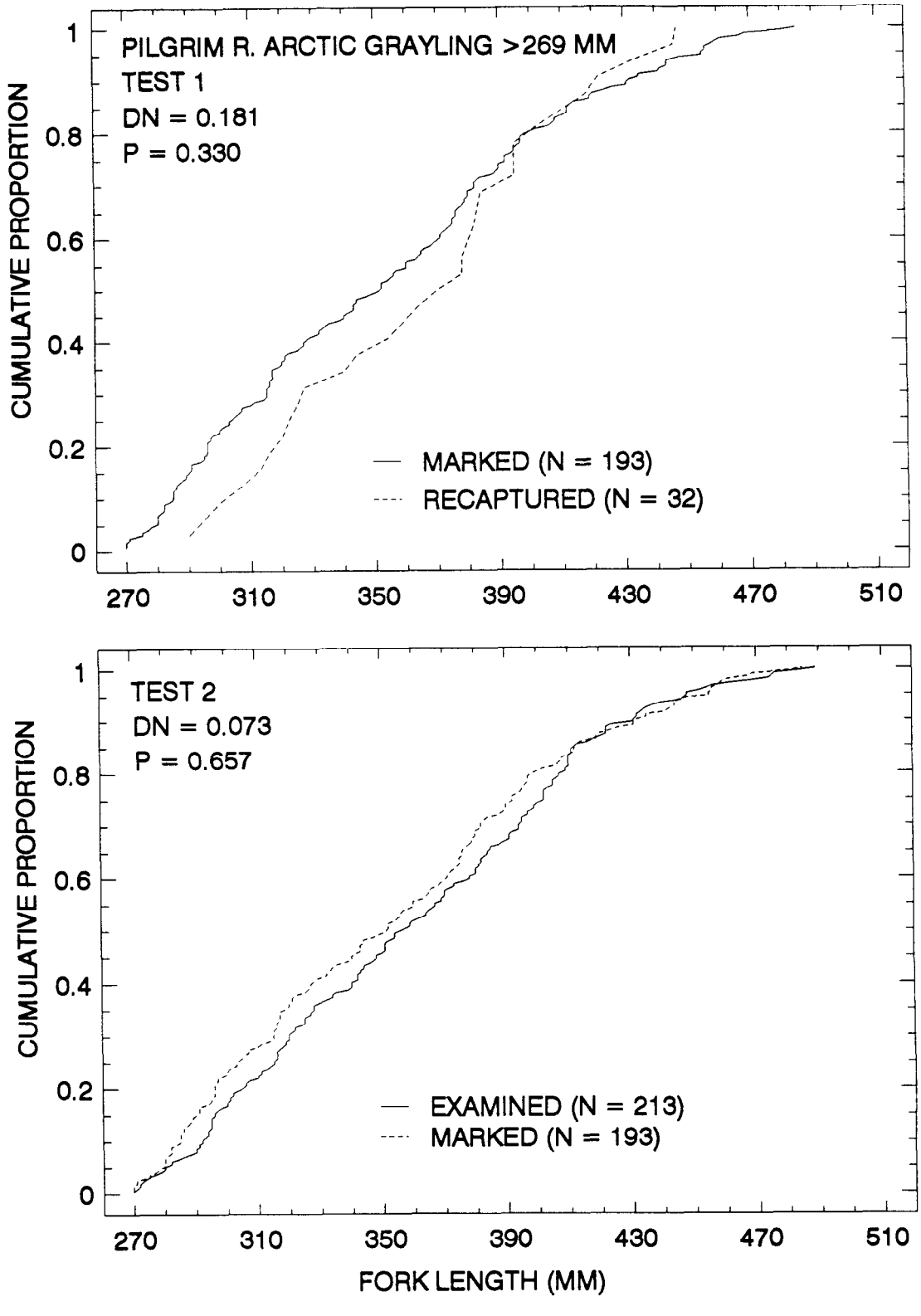

Figure 8. Cumulative length distribution plots (tests 1 and 2) of Arctic grayling >269 mm FL sampled from the Pilgrim River in 1992.

The abundance of Arctic grayling > 324 mm FL in a 40 km section of the Sinuk River in just prior to August 1991, estimated from data collected during 1989, 1990, 1991, and 1992 was 919 fish (SE = 196, CV = 21.3%). Density of Arctic grayling in the area sampled was 23 fish/km.

The modified Jolly-Seber estimate of survival from 1989 to 1990 was 1.00 (SE = 0.05) and from 1990 to 1991 was 0.65 (SE = 0.13). During the marking event in 1989, 138 tagged Arctic grayling were released in the Sinuk River. During 1990, 236 Arctic grayling were examined, of which 22 were marked in 1989. During 1991, 325 Arctic grayling were examined of which 40 carried 1990 marks and 31 carried 1989 marks.

The 1991 sample of Arctic grayling > 324 mm FL was used to estimate age and length composition for that year, and the sample from 1992 is also presented (Appendix A7).

Age Composition

Although Arctic grayling sampled during 1992 ranged from age 2 fish collected from the Snake River to age 15 fish collected from the Sinuk River, estimates of age composition and abundance by age class were restricted to: (1) fish > 249 mm FL on the Snake River, (2) fish > 269 mm FL from the Nome and Pilgrim rivers; and, (3) fish > 324 mm FL from the Sinuk River in 1991 (Table 2). The numbers of fish in each age class from the Snake, Nome and Pilgrim rivers (rivers for which estimates were germane to about the same length ranges) were compared and found to be significantly different (χ^2 = 93.38, df = 14, P < 0.001). Most of the differences were in age-4 fish and age-8 and older fish. Age-4 fish were more abundant than expected in the Snake River and less than expected in the Pilgrim River. Age-8 and older fish were more abundant than expected in the Pilgrim River and less abundant than expected in the Snake and Nome rivers.

Arctic grayling aged 7, 8 or 9 comprised 54.8% of fish sampled from the Sinuk River in 1992. The occurrence of age 6 and older Arctic grayling in the Sinuk River in 1991 was different from that in the 1992 sample (adjusted by one year; χ^2 = 20.17, df = 4, P <0.001). Ages of fish from other rivers were more evenly distributed (Figure 9). The oldest Arctic grayling sampled during 1992 were 11 years from the Snake River, 12 years from the Nome and Pilgrim rivers, and 15 years from the Sinuk River.

Length Composition

Length composition of Arctic grayling stocks sampled within the study area was estimated as RSD categories (Figure 10). The majority of Arctic grayling sampled from all rivers were in the preferred or memorable categories (Table 3).

Preferred and memorable fish comprised 52% and 47%, respectively, of the estimated size composition in the Sinuk River in 1991. No fish in the trophy category were encountered in any river. Few fish of stock size and smaller were sampled except in the Snake River where it appeared that good recruitment of smaller fish occurred in 1992. The Arctic grayling sample from the Sinuk River during 1992 was composed of 2% stock, 17% quality, 35% preferred, and 45% memorable fish. Examination of size distribution of all Arctic grayling

Table 2. Estimates of age composition and abundance of Arctic grayling from the Snake, Nome, and Pilgrim rivers in 1992 and from the Sinuk River in 1991.

Age	2	3	4	5	6	7	8	9	10	11	12	>12	Totals
Snake R. (fish >249 mm FL)													
N[a]	---	5	146	78	39	40	15	27	11	2	0	0	363
P[b]	---	0.01	0.40	0.21	0.11	0.11	0.04	0.07	0.03	<0.01	0.00	0.00	1.00
SE[c]	---	<0.01	0.03	0.02	0.02	0.02	0.01	0.01	0.01	<0.01	0.00	0.00	
Abundance[d]	---	33	973	520	260	266	100	180	73	13	0	0	2,418
SE[e]	---	15	101	67	45	45	27	36	23	9	0	0	200
Nome R. (fish >269 mm FL)													
N	---	---	87	67	45	32	13	9	44	0	1	0	258
P	---	---	0.34	0.26	0.17	0.12	0.05	0.03	0.02	0.00	<0.01	0.00	1.00
SE	---	---	0.03	0.03	0.02	0.02	0.01	0.01	<0.01	0.00	<0.01	0.00	
Abundance	---	---	244	188	126	90	37	25	11	0	3	0	725
SE	---	---	38	31	24	19	11	9	6	0	3	0	93
Pilgrim R. (fish >269 mm FL)													
N	---	9	67	44	35	42	43	35	17	6	2	0	300
P	---	0.03	0.22	0.15	0.12	0.14	0.14	0.12	0.06	0.02	<0.01	0.00	1.00
SE	---	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	<0.01	<0.01	0.00	
Abundance	---	38	282	185	147	176	181	147	71	25	8	0	1,263
SE	---	14	54	39	33	37	38	33	20	11	6	0	199
Sinuk R. 1991 (fish >324 mm FL)													
N	---	---	5	10	20	46	68	47	35	15	5	3	254
P	---	---	0.02	0.04	0.08	0.18	0.27	0.19	0.14	0.06	0.02	0.01	1.00
SE	---	---	<0.01	0.01	0.02	0.02	0.03	0.02	0.02	0.01	<0.01	<0.01	
Abundance	---	---	22	36	72	166	245	169	126	54	18	11	919
SE	---	---	10	13	22	41	58	42	33	18	9	7	196

[a] The sample size.
[b] The estimated proportion in the age class.
[c] Standard error of the proportion.
[d] Estimated abundance in river section by age class.
[e] Standard error of the abundance estimate.

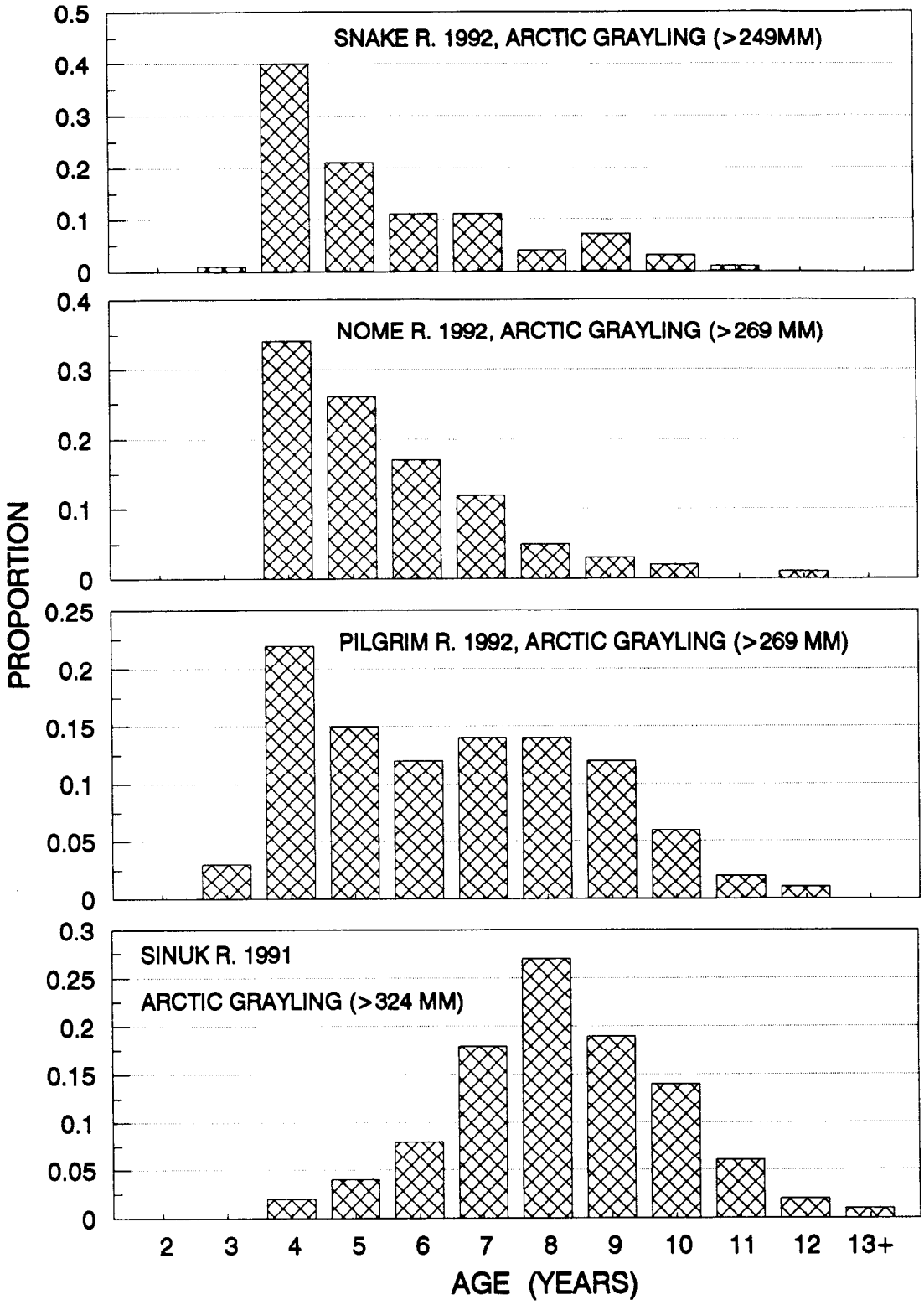

Figure 9. Age composition estimates of Arctic grayling from the Snake, Nome, and Pilgrim rivers during 1992 and from the Sinuk River during 1991.

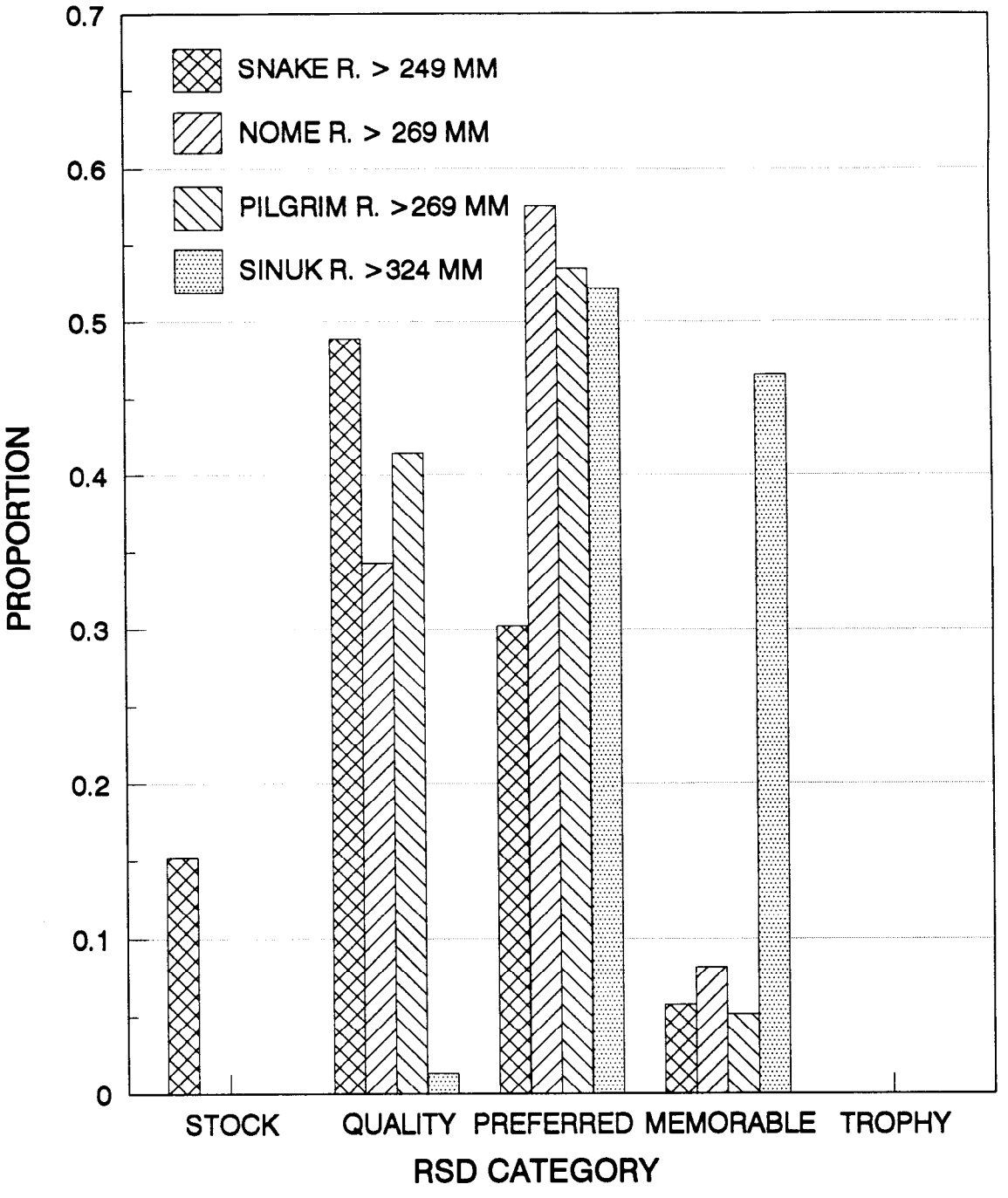

Figure 10. Length composition estimates as Relative Stock Density categories for Arctic grayling from the Snake, Nome, and Pilgrim rivers in 1992 and the Sinuk River in 1991.

Table 3. Number and proportion of Arctic grayling sampled and estimated abundances by RSD category in the Snake, Nome, and Pilgrim rivers during 1992 and the Sinuk River during 1991.

	RSD Category[a]				
	Stock	Quality	Preferred	Memorable	Trophy
Snake River (fish >249 mm FL)					
Number sampled	92[b]	296	183	35	0
RSD	0.15	0.49	0.30	0.06	0.00
Standard Error	0.01	0.02	0.02	0.01	0.00
Abundance	367	1,181	730	140	0
Standard Error	46	109	75	26	0
Nome River (fish >269 mm FL)					
Number sampled	---	105	176	25	0
RSD	---	0.34	0.58	0.08	0.00
Standard Error	---	0.03	0.03	0.02	0.00
Abundance	---	249	417	59	0
Standard Error	---	37	57	14	0
Pilgrim River (fish >269 mm FL)					
Number sampled	---	169	218	21	0
RSD	---	0.41	0.53	0.05	0.00
Standard Error	---	0.02	0.02	0.01	0.00
Abundance	---	523	674	65	0
Standard Error	---	88	111	17	0
Sinuk River 1991 (fish >324 mm FL)					
Number sampled	---	4	157	140	0
RSD	---	0.01	0.52	0.47	0.00
Standard Error	---	0.01	0.03	0.03	0.00
Abundance	---	12	479	428	0
Standard Error	---	6	105	95	0

[a] Minimum lengths for RSD categories (Gabelhouse 1984) are: stock 150 mm FL; quality - 270 mm FL; preferred - 340 mm FL; memorable - 450 mm FL; and, trophy - 560 mm FL.

[b] Estimate is only for fish >249 mm FL and <270 mm FL.

>101 mm FL sampled during 1992 (Table 4) shows that the majority of Arctic grayling sampled from some rivers represent limited length ranges. In the Snake River 57% of the Arctic grayling were between 250 and 350 mm FL. Arctic grayling in Sinuk River were larger with 68% being > 400 mm FL. Arctic grayling in the Snake, Nome, and Pilgrim rivers were more uniformly distributed by length (Figure 11).

Mean Length-at-Age

Estimates of mean fork length-at-age were calculated for Arctic grayling sampled from the Nome, Snake, Pilgrim and Sinuk rivers (Table 5). If data were available, they were combined across years (Appendix A8). Arctic grayling in all rivers were approximately the same size at age through age 3 after which fish from the Sinuk and Nome rivers were larger at most age classes. Increases in mean fork length of Arctic grayling from the Sinuk River was very rapid through age 7, the probable age at first maturity for fish from that river. At age 8 and older, average annual increase in length was small. Similar patterns of growth were less apparent for fish sampled from the Snake, Pilgrim, and Nome rivers where fish continued to increase in fork length at older ages. Age and length distributions of Arctic grayling sampled are provided in Appendices A3, A4, A5 and A6.

Growth

Annual mean change in fork length of 96 marked Arctic grayling recaptured one year later from the Sinuk River was 6.8 mm (Figure 12). Inspection of this figure shows that a year of growth in fish > 450 mm FL cannot be detected as increase in length. The measured growth increment increased to 9.8 mm (n = 44) after two years, and to 12.4 mm (n = 9) after three years.

DISCUSSION

Estimates of abundance of Arctic grayling residing in all study rivers except the Sinuk River were achieved within desired precision goals. The realized precision of estimates at $\alpha = 0.10$ were as follows: Snake River ± 14%, Pilgrim River ± 26%, Nome River ± 21%, and Sinuk River ± 35%.

Abundance estimates reported for the rivers apply only to the sections sampled and the size ranges indicated, and are thought to be unbiased. Age and size composition estimates similarly apply only to the indicated size ranges.

Equal probability of capture by size occurred during both sampling events on the Pilgrim River, so both samples were used to estimate age and size composition. In the Snake River, both events were size selective. In the Nome River, only event 1 was size selective. Thus, in the Snake River, we had to correct for size selective sampling, while in the Nome River we used data from sample two to get an unbiased estimate. A combination of gear types were used to sample fish in all rivers and it is thought that samples represent length ranges of fish present within the reach of each river sampled. Small sized Arctic grayling (< 300 mm FL) were not common in any river sampled except the Snake River where good recruitment of small (250 - 300 mm FL) fish occurred in 1992. In 1991, this group of fish (< 200 mm FL at that time) were not commonly found within the sampling area. However, small Arctic grayling

Table 4. Length composition in 25 mm increments of Arctic grayling >101 mm fork length sampled from Seward Peninsula rivers during 1992.

Fork Length Range (mm)	Snake River Sampled Fish	Snake River Proportion	Snake River Standard Error	Nome River Sampled Fish	Nome River Proportion	Nome River Standard Error
101 - 125	0	0.000	---	0	0.000	---
126 - 150	0	0.000	---	0	0.000	---
151 - 175	1	0.001	---	0	0.000	---
176 - 200	13	0.011	0.003	0	0.000	---
201 - 225	25	0.021	0.004	2	0.005	0.003
226 - 250	56	0.048	0.006	5	0.012	0.005
251 - 275	173	0.149	0.010	13	0.031	0.008
276 - 300	201	0.173	0.011	59	0.138	0.017
301 - 325	139	0.119	0.016	69	0.162	0.018
326 - 350	147	0.126	0.010	77	0.181	0.019
351 - 375	98	0.084	0.008	50	0.116	0.016
376 - 400	78	0.067	0.007	49	0.115	0.015
401 - 425	88	0.076	0.008	42	0.099	0.014
426 - 450	87	0.075	0.008	36	0.085	0.013
451 - 475	39	0.034	0.005	18	0.042	0.010
476 - 500	19	0.016	0.004	6	0.014	0.006
Total 101 - 500	1,164	1.000		426	1.000	

Fork Length Range (mm)	Pilgrim River Sampled Fish	Pilgrim River Proportion	Pilgrim River Standard Error	Sinuk River Sampled Fish	Sinuk River Proportion	Sinuk River Standard Error
101 - 125	0	0.000	---	3	0.010	0.006
126 - 174	0	0.000	---	0	0.000	---
151 - 175	0	0.000	---	0	0.000	---
176 - 200	0	0.000	---	2	0.007	0.005
201 - 225	1	0.002	---	0	0.000	---
226 - 250	12	0.028	0.008	1	0.003	---
251 - 275	30	0.069	0.012	4	0.014	0.007
276 - 300	68	0.156	0.017	12	0.042	0.012
301 - 325	64	0.147	0.017	24	0.083	0.016
326 - 350	47	0.108	0.015	16	0.055	0.013
351 - 375	56	0.128	0.016	13	0.045	0.012
376 - 400	65	0.149	0.017	16	0.055	0.013
401 - 425	47	0.108	0.015	31	0.107	0.018
426 - 450	25	0.057	0.011	43	0.149	0.021
451 - 475	16	0.037	0.009	71	0.246	0.025
476 - 500	5	0.011	0.005	43	0.149	0.021
501 - 525	0	0.000	---	10	0.035	0.011
Total 151 - 550	436	1.000		289	1.000	

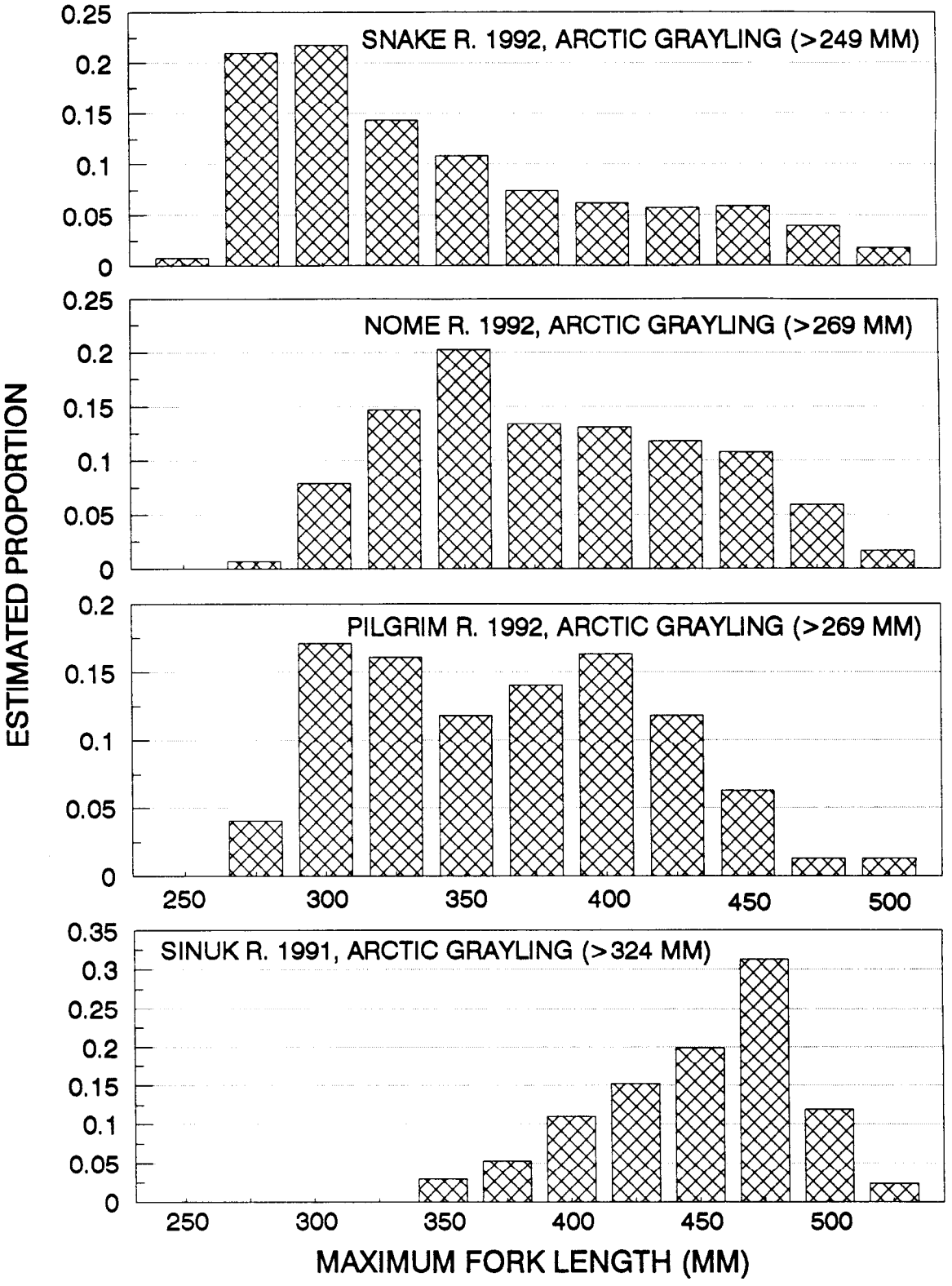

Figure 11. Length composition estimates in 25 mm increments of Arctic grayling from the Snake, Nome and Pilgrim rivers in 1992 and the Sinuk River in 1991.

Table 5. Mean fork length-at-age of Arctic grayling sampled in Seward Peninsula rivers during 1992.

Age	Snake River			Nome River			Pilgrim River			Sinuk River		
	Number of Fish	Fork Length (mm)	Standard Deviation FL (mm)	Number of Fish	Fork Length (mm)	Standard Deviation FL (mm)	Number of Fish	Fork Length (mm)	Standard Deviation FL (mm)	Number of Fish	Fork Length (mm)	Standard Deviation FL (mm)
1	---	---	---	---	---	---	---	---	---	3	109	12
2	14	208	16	1	223	---	---	---	---	2	210	41
3	19	269	27	---	---	---	11	284	32	2	271	11
4	275	285	33	103	320	28	80	296	33	25	319	45
5	176	319	31	97	362	32	47	322	33	29	344	38
6	92	352	32	103	352	35	35	352	36	8	391	34
7	68	389	37	66	401	36	43	369	49	32	445	41
8	54	419	39	51	427	31	44	396	41	43	453	39
9	62	429	29	23	439	19	35	408	39	44	456	30
10	33	435	22	15	445	17	17	410	29	20	460	31
11	15	443	21	1	476	---	6	413	59	11	464	11
12	3	438	34	2	485	2	2	463	43	---	---	---
13	---	---	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---	---	---	---
15	---	---	---	---	---	---	---	---	---	1	495	---

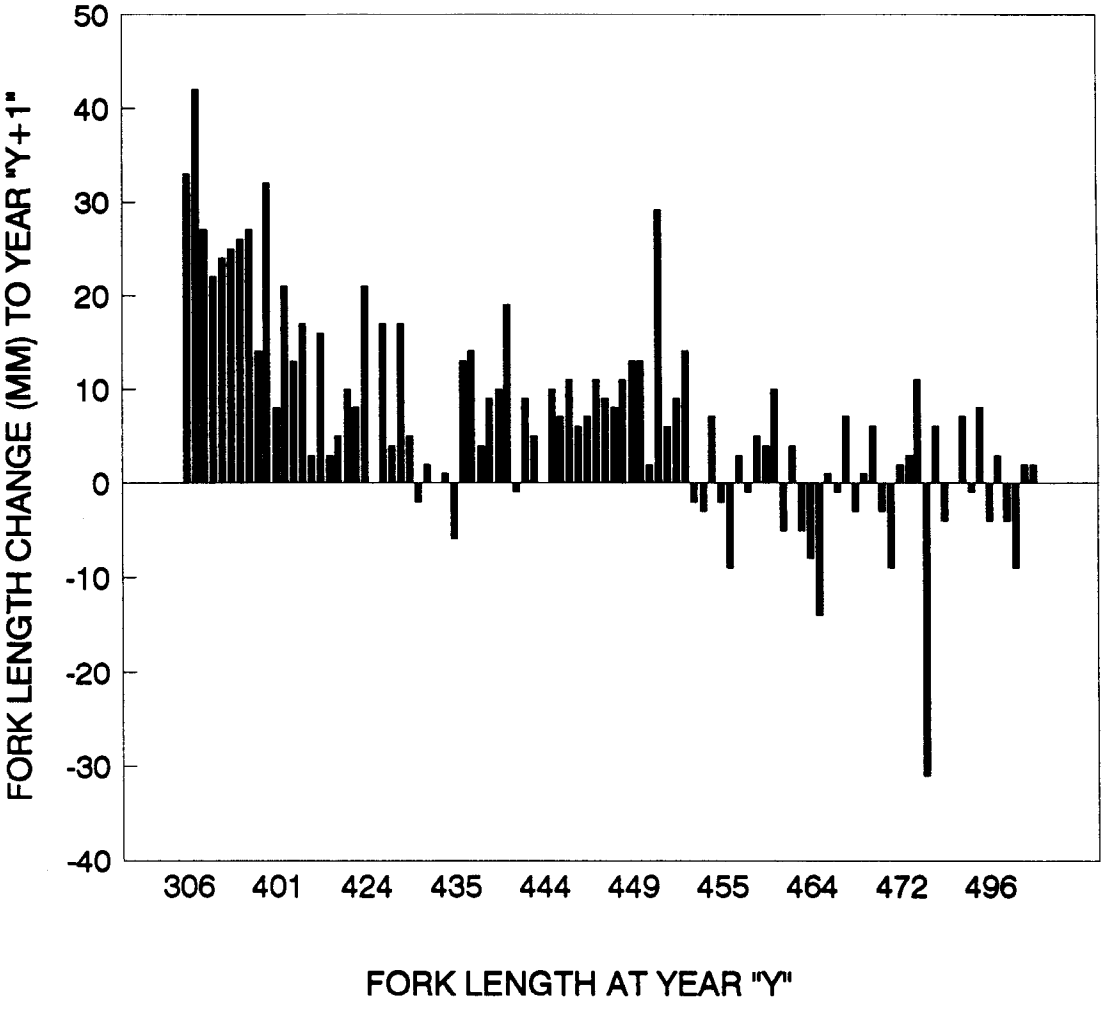

Figure 12. Annual change in measured fork length of marked Arctic grayling recaptured after one year in the Sinuk River (1989 - 1992).

were found in small lower river tributary streams and in connected oxbow lakes. This group of fish should carry through the population during upcoming years.

The relative lack of small sized Arctic grayling in samples from other rivers suggests that young fish occupy different areas or habitats than were sampled during recent years, and recruitment will not be observed until fish reach about 300 mm FL.

Based on observations during 1991 (DeCicco 1992), the sampling area on the Snake River was extended 20 km farther upstream in 1992. This afforded the ability to sample nearly the entire Arctic grayling population in the mainstem portion of this river. Continued sampling of the entire mainstem river is recommended, however a single sampling event, and Jolly-Seber estimator should simplify data gathering and provide estimates of abundance, survival and recruitment which will be adequate for management of this population.

The abundance of Arctic grayling in the Nome River was estimated at 430 fish in 1991 (DeCicco 1992). This year's estimate (725 fish) was much more precise because of larger sample sizes. The presence of a near record abundance of pink salmon caused the Arctic grayling to concentrate in sloughs and slack water areas increasing our ability to capture them. This condition cannot be expected to occur in 1993. Since sport fishing for Arctic grayling was closed in the Nome River in 1992, and is expected to remain closed until the population recovers, it is recommended that no sampling take place in the Nome River during the next two or three years to encourage this recovery. After that time, population assessment should be resumed so a responsible decision regarding opening the fishery may be considered.

Population assessment work in both the Pilgrim and the Sinuk rivers should be continued. The Sinuk River was the least exploited area sampled. Arctic grayling average size was large (445 mm FL), fish attained large maximum size with fish > 520 mm FL having been sampled each year, and great age. Although fish were aged to 15 years with scales, the few otolith samples available suggested that older fish may be under aged. This observation is consistent with other studies comparing otoliths to scales in Arctic grayling (Merritt and Fleming 1991, Craig and Poulin 1975, Schmidt and Stratton 1984). Considering that age 9 (scale) fish were aged 14 using otoliths, and age 12 fish (scale) were aged 18 using otoliths, fish over 20 years of age may typically be present in this and other Arctic grayling populations on the Seward Peninsula. Scales from many recaptured fish showed no detectable growth after one year. Since recaptured Sinuk River grayling changed little in length after one year (< 7 mm), large fish may be commonly underaged using scales. Thus, the age structure for large fish (> 430 mm FL) should be viewed with caution.

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APPENDIX A

Appendix A1. List of numbered tags and finclips used to mark Arctic grayling sampled from the Snake, Nome, Pilgrim, and Sinuk rivers during 1992.

Location	Total Fish	Tag Numbers	Color	Fin Clip
Snake River	90	27910 - 27999	Blue	Right Pectoral
	308	28575 - 28882	Blue	Right Pectoral
	117	28883 - 28999	Blue	Right Pectoral
	24	29000 - 29023	Blue	Right Pectoral
	117	29025 - 29141	Blue	Right Pectoral
	138	29143 - 29280	Blue	Right Pectoral
Pilgrim River	5	53639 - 53643	Green	Left Pelvic
	25	53645 - 53669	Green	Left Pelvic
	54	53671 - 53724	Green	Left Pelvic
	252	53726 - 53977	Green	Left Pelvic
Nome River	77	52773 - 52849	Green	Right Pectoral
	57	52943 - 52999	Green	Right Pectoral
	42	55000 - 55041	Green	Right Pectoral
	147	55043 - 55189	Green	Right Pectoral
Sinuk River	198	51602 - 51799	Green	Left Pelvic
	26	51815 - 51840	Green	Left Pelvic

Appendix A2. Inference as a means to detect bias due to gear selectivity.

Results of Hypothesis Tests (K-S and χ^2) on Lengths of Fish Marked during First First Event and Recaptured during Second Event	Results of Hypothesis Tests (K-S) on Lengths of Fish Captured during First Event and during Second Event
Case I:	
"Accept" H_o	"Accept" H_o
There is no size-selectivity during either sampling event.	
Case II:	
"Accept" H_o	Reject H_o
There is no size-selectivity during the second sampling event but there is during the first.	
Case III:	
Reject H_o	"Accept" H_o
There is size-selectivity during both sampling events.	
Case IV:	
Reject H_o	Reject H_o
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

Case III: Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data.

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Also, calculate a single estimate of abundance without stratification.

-continued-

Case IVa:	If the stratified and unstratified abundance estimates for the entire population are dissimilar, discard the unstratified estimate. Only use the lengths, ages, and sexes from the second sampling event to estimate proportions in composition, and apply formulae to correct for size bias to data from the second event.
Case IVb:	If the stratified and unstratified abundance estimates for the entire population are similar, discard the estimate with the larger variance. Only use the lengths, ages, and sexes from the first sampling event to estimate proportions in compositions, and do not apply formulae to correct for size bias.

Appendix A3. Age-length distribution of Arctic grayling sampled from the Snake River during 1992.

Fork Length (mm)	AGE (Years) 1	2	3	4	5	6	7	8	9	10	11	12	13	
76 to 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101 to 125	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126 to 150	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151 to 175	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176 to 200	0	4	0	0	0	0	0	0	0	0	0	0	0	4
201 to 225	0	7	1	3	0	0	0	0	0	0	0	0	0	11
226 to 250	0	3	4	27	2	0	0	0	0	0	0	0	0	36
251 to 275	0	0	9	91	15	1	0	0	0	0	0	0	0	116
276 to 300	0	0	2	85	35	4	0	1	0	0	0	0	0	127
301 to 325	0	0	3	39	40	13	3	0	0	0	0	0	0	98
326 to 350	0	0	0	18	55	30	9	1	1	0	0	0	0	114
351 to 375	0	0	0	8	27	22	11	1	1	0	0	0	0	70
376 to 400	0	0	0	3	2	15	21	8	6	3	0	0	0	58
401 to 425	0	0	0	0	0	5	14	21	17	9	2	1	0	69
426 to 450	0	0	0	0	0	0	8	9	28	12	9	0	0	66
451 to 475	0	0	0	1	0	0	1	9	8	8	2	2	0	31
476 to 500	0	0	0	0	0	0	1	3	2	1	2	0	0	9
Totals	0	14	19	275	176	90	68	53	63	33	15	3	0	809

Appendix A4. Age-length distribution of Arctic grayling sampled from the Nome River during 1992.

Fork Length (mm)	AGE (Years)													
	1	2	3	4	5	6	7	8	9	10	11	12	>12	
76 to 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101 to 125	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126 to 150	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151 to 175	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176 to 200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201 to 225	0	1	0	0	0	0	0	0	0	0	0	0	0	1
226 to 250	0	0	0	0	0	0	0	0	0	0	0	0	0	0
251 to 275	0	0	0	1	0	0	0	0	0	0	0	0	0	1
276 to 300	0	0	0	25	3	0	0	0	0	0	0	0	0	28
301 to 325	0	0	0	30	10	2	0	0	0	0	0	0	0	42
326 to 350	0	0	0	37	21	3	0	0	0	0	0	0	0	61
351 to 375	0	0	0	7	30	9	3	0	0	0	0	0	0	49
376 to 400	0	0	0	1	23	17	7	0	0	0	0	0	0	48
401 to 425	0	0	0	0	8	19	12	5	3	0	0	0	0	47
426 to 450	0	0	0	0	2	11	20	13	6	2	0	0	0	54
451 to 475	0	0	0	1	0	3	4	5	6	4	0	0	0	23
476 to 500	0	0	0	0	0	2	5	0	0	2	1	2	0	12
Totals	0	1	0	102	97	66	51	23	15	8	1	2	0	366

Appendix A5. Age-length distribution of Arctic grayling sampled from the Pilgrim River during 1992.

Fork Length (mm)	AGE (Years)													
	1	2	3	4	5	6	7	8	9	10	11	12	>12	
76 to 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101 to 125	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126 to 150	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151 to 175	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176 to 200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201 to 225	0	0	0	1	0	0	0	0	0	0	0	0	0	1
226 to 250	0	0	2	8	0	0	0	1	0	0	0	0	0	11
251 to 275	0	0	3	9	5	0	1	0	0	0	0	0	0	18
276 to 300	0	0	3	27	8	2	2	0	1	0	0	0	0	43
301 to 325	0	0	2	23	14	8	2	3	0	0	0	0	0	52
326 to 350	0	0	1	9	8	6	2	9	1	0	1	0	0	37
351 to 375	0	0	0	2	10	9	11	10	4	0	0	0	0	46
376 to 400	0	0	0	0	2	8	16	11	7	7	1	0	0	52
401 to 425	0	0	0	1	0	1	6	5	12	5	1	0	0	31
426 to 450	0	0	0	0	0	1	2	5	5	4	1	1	0	19
451 to 475	0	0	0	0	0	0	0	0	4	1	2	0	0	7
476 to 500	0	0	0	0	0	0	0	0	1	0	0	1	0	2
Totals	0	0	11	80	47	35	42	44	35	17	6	2	0	319

Appendix A6. Program RECAP output for Sinuk River, 1992.

Output 1: data truncated for fish >324 mm FL.

S= 4

	NS	MS	RR	R	G	Z	ALPHA	BETA	
1	137	0	57	137	0	0	0	0	Aug 1989
2	226	24	57	225	0	33	0	0	Aug 1990
3	298	71	38	296	0	19	0	0	Aug 1991
4	207	57	0	207	0	0	0	0	Aug 1992

JOLLY-SEBER ESTIMATES:

	MP	NP	B	PHI
1				1.1260
2	154.26	1453	24.	.6164
3	219.00	919.		

STANDARD ERRORS OF JOLLY-SEBER ESTIMATES:

	MP	NP	B	PHI
1				.1768
2	24.62	347.	197.	.1201
3	38.82	181.		

MODIFIED ESTIMATES:

I	MP	NP	B	PHI	P	NU	MU	ZETA
1				1.0000		1.0000	.0000	
2	137.00	1290.	84	.6479	.1752	.9956	.0000	.1062
3	219.00	919			.3242	.9933		.2383

STANDARD ERRORS OF MODIFIED ESTIMATES ESTIMATED FROM 400 SIMULATIONS:

I	MP	NP	B	PHI	P	NU	MU
1				.0522		.0000	.0000
2	13.72	196.	127	.1260	.0319	.0049	.0000
3	43.89	196.			.0659	.0047	

95% "EQUAL TAILS" CONFIDENCE INTERVALS ESTIMATED FROM 400 SIMULATIONS:

I	MP		NP		B		PHI	
	L	U	L	U	L	U	L	U
1							.8003	1.0000
2	105.00	159.00	895.	1644.	0.	411.	.4569	.9200
3	152.37	322.19	636	1406.				

95% "MINIMUM LENGTH" CONFIDENCE INTERVALS ESTIMATED FROM 400 SIMULATIONS:

I	MP		NP		B		PHI	
	L	U	L	U	L	U	L	U
1							.8678	1.0000
2	110.43	163.00	928.	1661.	0.	378.	.4569	.9200
3	142.50	308.68	626.	1370.				

ESTIMATED AVERAGE NUMBER OF ANIMALS ALIVE
BETWEEN CAPTURE 2 AND CAPTURE 3 = 1105. WITH STANDARD
ERROR 147. AND 95% CONFIDENCE INTERVAL (862. , 1423.)

ESTIMATED GEOMETRIC MEAN OF THE PROBABILITIES OF SURVIVAL
BETWEEN CAPTURE 1 AND CAPTURE 3 = .8049 WITH STANDARD
ERROR .0757 AND 95% CONFIDENCE INTERVAL (.6759 , .9575)

ESTIMATED AVERAGE NUMBER OF BIRTHS BETWEEN CAPTURE 2 AND CAPTURE 3 = 84.
WITH STANDARD ERROR 127. AND 95% CONFIDENCE INTERVAL (0., 378.)

Appendix A7. Age-length distribution of Arctic grayling sampled from the Sinuk River during 1992.

	AGE (Years)													
Fork Length (mm)	1	2	3	4	5	6	7	8	9	10	11	12	>12	
76 to 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101 to 125	3	0	0	0	0	0	0	0	0	0	0	0	0	3
126 to 150	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151 to 175	0	0	0	0	0	0	0	0	0	0	0	0	0	0
176 to 200	0	1	0	0	0	0	0	0	0	0	0	0	0	1
201 to 225	0	0	0	0	0	0	0	0	0	0	0	0	0	0
226 to 250	0	1	0	0	0	0	0	0	0	0	0	0	0	1
251 to 275	0	0	1	2	0	0	0	0	0	0	0	0	0	3
276 to 300	0	0	1	8	1	0	0	0	0	0	0	0	0	10
301 to 325	0	0	0	8	10	0	1	0	0	0	0	0	0	19
326 to 350	0	0	0	4	7	1	0	1	0	0	0	0	0	13
351 to 375	0	0	0	1	4	1	0	1	0	0	0	0	0	7
376 to 400	0	0	0	1	5	2	1	1	2	1	0	0	0	13
401 to 425	0	0	0	0	2	4	6	7	4	1	0	0	0	24
426 to 450	0	0	0	0	0	0	9	7	8	5	1	0	0	30
451 to 475	0	0	0	0	0	0	5	12	19	7	10	0	0	53
476 to 500	0	0	0	0	0	0	8	10	8	5	1	0	1	33
501 to 525	0	0	0	0	0	0	1	4	3	1	0	0	0	9
Totals	3	2	2	24	29	8	31	43	44	20	12	0	1	218

Appendix A8. Mean fork length-at-age of Arctic grayling in Seward Peninsula rivers sampled during 1992.

Age	Snake River 1991 - 1992 Number of Fish	Fork Length (mm)	Standard Deviation FL (mm)	Nome River 1991 - 1992 Number of Fish	Fork Length (mm)	Standard Deviation FL (mm)	Pilgrim River 1990 - 1992 Number of Fish	Fork Length (mm)	Standard Deviation FL (mm)	Sinuk River 1989 - 1992 Number of Fish	Fork Length (mm)	Standard Deviation FL (mm)
1	29	139	67	1	125	0	---	---	---	3	109	12
2	14	208	16	1	223	0	2	207	34	3	209	29
3	132	269	25	19	257	23	53	263	28	6	272	24
4	482	285	31	122	319	28	136	295	29	48	322	39
5	307	319	31	118	364	34	101	323	33	70	359	46
6	195	352	34	140	363	38	163	354	34	101	418	45
7	150	389	41	92	412	38	175	380	40	180	443	32
8	148	416	34	64	433	31	140	405	35	179	449	37
9	145	432	28	24	439	19	112	425	35	122	451	35
10	58	434	23	18	452	22	49	429	34	71	453	34
11	15	443	21	1	476	0	15	435	51	39	469	26
12	3	438	34	3	488	6	6	461	21	6	464	25
13	---	---	---	---	---	---	---	---	---	4	493	29
14	---	---	---	---	---	---	---	---	---	---	---	---
15	---	---	---	---	---	---	---	---	---	2	497	3

APPENDIX B

Appendix B1. Data files used to estimate parameters of Arctic grayling populations on the Seward Peninsula in 1992.

Data file[a]	Description
W0120LB2.DTA	Mark and recapture data for Arctic grayling captured from the Snake River during 1992.
W0040LA2.DTA	Mark and recapture data for Arctic grayling captured from the Nome River during 1992.
W0060LA2.DTA	Mark and recapture data for Arctic grayling captured from the Pilgrim River during 1992.
W0020LA2.DTA	Mark and recapture data for Arctic grayling captured from the Sinuk River during 1992.

[a] Data files have been archived at, and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.